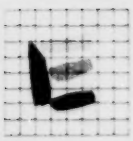
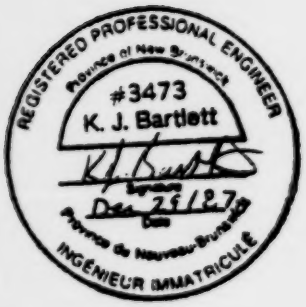


CANADA/NEW BRUNSWICK
CONSERVATION AND
ALTERNATIVE ENERGY AGREEMENT

L'ENTENTE CANADA/NOUVEAU-BRUNSWICK
SUR LES ÉCONOMIES D'ÉNERGIE
ET LES ÉNERGIES DE REMPLACEMENT

REPORT

A STUDY OF THE ECONOMIC AVAILABILITY OF WOOD RESIDUES FOR FUEL IN NEW BRUNSWICK



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EXECUTIVE SUMMARY

This report documents an investigation into the production and utilization of wood residues generated in the Province of New Brunswick. The study was conducted during the summer of 1987. Wood residues are subclassified as either "harvest" residues or"processing" residues and, in both cases, are defined generally as biomass material which remains after the production of the primary product or products.

Detailed data on residue production by primary wood producers and by wood processing plants was assembled and catalogued in a computer program which forms a part of the final report. This information is to assist with the investigation of specific future projects which may require the acquisition of wood residues for use as a fuel.

Detailed data on the users of New Brunswick residue, both within the Province and in adjacent provinces and the USA, was also catalogued and included in the computer program.

Other sections of the report deal with the calculation of the heating value of various types of residue fuels and with the development of costs for processing and transportation of wood residues from their source to the point of utilization. The computer program includes these analyses to allow a user to quickly generate estimated costs for a specific case on an interactive basis.

Significant findings of the study include:

1. Approximately 85 percent or 856,000 bone dry tonnes (B.D.T.) of a total of 1,006,429 B.D.T. of wood processing residue produced in the Province each year is now being used as fuel rather than being incinerated or dumped.

2. Since 1982, annual wood residue consumption has increased by more than 525,000 B.D.T., with new, large-scale industrial boilers accounting for most of the increase.

3. Any major expansion of wood energy use will require the development of fuel supplies in addition to the small unallocated supply of wood processing residues.

4. Harvest residues represent a large, almost untapped source of wood fuel with an estimated total availability of 2,706,340 B.D.T. per annum based on present harvesting levels. This amounts to approximately 500 vanloads of wood fuel per day, with a usable energy potential equal to approximately 2.67 million litres of #6 fuel oil per day. Unlike nonmerchantable stands or surplus species stands of wood, harvest residue has no potential for higher-value-added usage, and, for this reason, should be developed as the next major source of biomass fuel in the province.

SOMMAIRE À L'INTENTION DE LA DIRECTION

Le présent rapport dresse le bilan d'une étude sur la production et l'utilisation des résidus de bois générés dans la province du Nouveau-Brunswick. Cette étude a été effectuée au cours de l'été 1987. Il existe deux catégories de résidus du bois : les résidus "d'abattage" et les résidus de "transformation". Dans les deux cas, il s'agit de la biomasse spécifique restante après la production d'un ou de plusieurs produits primaires.

Des données détaillées sur les résidus issus des activités des producteurs de bois du secteur primaire et des usines de transformation du bois ont été compilées, puis emmagasinées dans un programme informatique, lequel constitue une partie du rapport final. Ces données visent à favoriser l'élaboration future de projets particuliers dans le cadre desquels on pourrait avoir à se procurer des résidus de bois en guise de combustible.

Des données détaillées sur les utilisateurs de résidus de bois du Nouveau-Brunswick, des provinces limitrophes et des États-Unis ont également été compilées et emmagasinées dans le programme informatique.

D'autres sections du rapport portent sur la quantité de chaleur qu'on peut tirer de la combustion de différents types de résidus ainsi que sur le coût de transformation des résidus et les frais de transport de ceux-ci, de leur point d'origine au lieu d'utilisation. Ces analyses ont également été emmagasinées dans le programme informatique, permettant ainsi à l'utilisateur d'obtenir une estimation des coûts dans un cas précis et en tenant compte de toutes les interactions.

Voici quels sont les principaux résultats de l'étude.

1. Environ 85 % des résidus de bois générés annuellement par les usines de transformation de la province, soit 856 000 tonnes de résidus absolument secs (T.A.S.) sur un total de 1 006 429 tonnes, sont aujourd'hui utilisés plutôt que simplement incinérés ou jetés.

2. Depuis 1982, la consommation annuelle de résidus de bois a augmenté de plus de 525 000 T.A.S., augmentation attribuable en grande partie aux grosses chaudières industrielles.

3. Toute augmentation importante de l'utilisation de l'énergie du bois exigera la création d'approvisionnements venant s'ajouter aux petites réserves non attribuées de résidus de bois.

4. Les résidus d'abattage constituent une source importante de bois de chauffage pratiquement inexploitée, atteignant un total disponible estimé à 2 706 340 T.A.S. par année, compte tenu des présents niveaux d'abattage. Cela équivaut à environ 500 pleins-wagnons de bois de chauffage par jour, l'équivalent de 2,67 millions de litres de mazout n° 6 par jour. Contrairement aux peuplements de bois non marchand ou aux peuplements d'essences excédentaires, les résidus d'abattage n'offrent aucun potentiel en ce qui a trait à l'augmentation de valeur due à l'utilisation et, pour cette raison, devraient être développés en tant que prochaine source importante d'énergie de biomasse dans la province.

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1.0 INTRODUCTION

1.1 Objective

The objective of the study is to determine the present availability and disposition of manufacturing and harvesting residues in the Province, and to develop projections of future availability and costs of residues for the years 1987 through 2007.

1.2 Background to the Study

A number of previous studies have been carried out by both the private and public sectors on the availability of wood residues in various parts of the Province.

Past studies have included an investigation of the economics of collecting harvesting residues in the Miramichi Watershed in 1984, and a southeast N.B. Marketing Board survey of sawmills in the Kent-Westmorland area which included estimates of harvesting residues available for fuel.

Numerous other studies have been conducted within the region and in the United states, some of which are cited as references for the present study.

The use of wood residue for fuel has greatly accelerated during the past decade.

Prior to 1973, wood residue was used almost exclusively by the pulp and paper industry, and then primarily out of the necessity to dispose of the residue rather than as a means to save money on fuel costs.

Sawmills generally disposed of waste products in teepee burners or by landfilling or dumping the unwanted material.

Since the oil price shocks of the mid to late seventies, there has been a realization that wood residue is a fuel resource whose value is closely tied to that of competing fuels such as Bunker "C" oil and Number 2 fuel oil. Pulp and paper mills in the Province have expanded their wood-burning capacity to absorb a higher percentage of sawmill residues from the surrounding region, and new industrial and institutional users of residue fuels have emerged.

The University of New Brunswick, for example, has installed a wood-burning boiler which supplies approximately 70 percent of the load on its central heating plant from the wood residue of sawmills in the region surrounding Fredericton.

Several provincial hospitals also depend primarily on sawmill residues to supply steam for space heating and laundry plants.

The Bellisle High School and the Madawaska Regional Correctional Centre also use sawmill wood residue as a primary fuel.

In the industrial sector outside the forest industry, small wood-burning units have been used at greenhouse installations, and studies have been conducted on large scale plants for major provincial industries who are not, themselves, producers of wood residues.

Perhaps most notable of these is the study of the potential use of wood residue as fuel for a 25 megawatt (mW) electric generating station in the Province.

All of this activity has created a fledgling market for processed wood residues capable of being handled by the automatic burning equiment that is in use at the many different sites in the Province.

The collection, processing and distribution of sawmill residue in the Fredericton area provides employment for several sawmill workers and truck drivers, and supports the jobs of workers at the larger wood burning sites. Thus additional employment is provided, while at the same time, saving overall cost to the end user of the residue and creating a value-added by-product for the residue supplier.

This type of economic activity is sensitive to the cost of competing fuel, however, which in New Brunswick means the cost of fuel oil.

During the recent decline of fuel oil prices, the potential return on investment to the owner of a new wood-burning facility has also declined to the point that most new projects are not attractive to private owners. In the longer term, however, fuel prices are expected to move higher, and development of the residue resource will continue.

It is against this background that the present study has been undertaken. Its purpose is to provide a comprehensive assessment of the present availability and consumption of residue and the outlook for future availability and potential costs.

Most of the field collected data assembled during the course of this work is included with the computer program which was developed specifically for this project. This represents a departure from previous studies of this type which typically have included only summary tables to represent the field data in a more compact form.

With the computer program, the user may focus on any particular aspect of the data base, or generate global reports which will provide a copy of most of the source data on residue production and consumption which was assembled for this project. Moreover, the database may be updated periodically, and the program may be modified to produce different types of reports.

The computer data files include a directory of firms and telephone numbers and contact people involved in the production and use of wood residues at this time.

1.3 Scope of Work

The present study includes the following areas of inquiry:

(a) Identification of the sources of residues of primary and secondary wood producers in New Brunswick.

(b) Identification of the sources of residues resulting from the processing and manufacturing of forest products in New Brunswick.

(c) Identification of consumers of residues in New Brunswick for fuel and other purposes.

(d) Identification of consumers of New Brunswick residue located in Maine, Quebec, Nova Scotia, and Prince Edward Island for fuel and other purposes.

(e) Determination of the quality (type, moisture content, size, and shape of residues) and quantity of residues for items (a) to (d) above.

(f) Determination of the cost of wood residues including a breakdown of this cost (basic cost, transportation, processing).

(g) Evaluation of the energy content of residues based on available information.

(h) Evaluation of the development of wood residue use in New Brunswick, Maine, and other areas directly affecting residue availability.

(i) Projection of the maximum availability, and cost of wood residues, up to the year 2007.

(j) Development of a computer model to present the results and to allow periodic future updating.

2.0 IDENTIFICATION OF SOURCES OF RESIDUES FROM PRIMARY AND SECONDARY WOOD PRODUCERS

2.1 Definition of Residues

Forest residues, for the purposes of this study, were grouped into two main categories, which are explained below:

a) **Slash:** Slash is a "generic" term generally used to denote the branches and tops of trees that remain after a harvesting operation. Depending on the logging method, these residues may be found at the stump or at roadside.

b) **Unmerchantable Timber:** It is probably inaccurate to describe any timber as "unmerchantable" in the long term due to future developments in markets and technology which can create higher value markets in the future for this resource. Unmerchantable timber is a broad phrase that is used to describe all forms of standing trees that do not have any existing commercial value due to their species or form. This definition may be further broken down as follows:

   i) Surplus Cutover Residuals - These are trees remaining after an area has been completely harvested for all commercial purposes and may include, for example, hardwoods or cedar in an area harvested for spruce and fir pulpwood.

   ii) Salvage Stands - Areas that have been burned over or heavily damaged by insects may not be suitable for the production of a product, but are readily available for use as a wood fuel.

iii) Sub-Marginal Stands - These stands are presently not economical to harvest in a conventional sense due to inadequate stocking, poor form, wrong species, etc., but the site is capable of producing good forest growth. If part or all of the material from these areas could be used as an energy source, it may become economically feasible to remove the current stand and enable silvicultural treatment of the site.

iv) Surplus Stands - These stands are presently not feasible to operate because there is no outlet for the product. A possible example would be stands of poplar in the southeastern part of the Province where there is no current market. Higher value uses for this resource would, of course, take precedence over fuel harvesting, where these uses can be developed either now, or in the foreseeable future.

2.2 Organization of Timber Harvesting Operations in New Brunswick

There are approximately 6 million hectares (15 million acres) of productive forest lands in New Brunswick. Approximately 18 percent of this is classified large industrial freehold, 33 percent as small freehold or private woodlots, 48 percent as Crown lands and 1 percent Federal land. Generally, the large freehold category includes sawmill and pulpmill owners of forest lands.

Figure 2.2.1 represents graphically the distribution of ownership of productive forest lands in New Brunswick.

FIGURE 2.2.1
DISTRIBUTION OF FOREST OWNERSHIP IN N. B.

Harvesting operations in New Brunswick are carried on under two different administrative units. They are: (1) Crown Licensees and SubLicensees; and (2) Marketing Boards.

2.2.1 Crown Licensees

There are 10 Crown licensees in New Brunswick.

License	Licensee
1. Upsalquitch	NBIP Forest Products Inc.
2. Nepisiguit	Consolidated-Bathurst Inc.
3. Lower Miramichi	Miramichi Pulp and Paper Inc.
4. Upper Miramichi	Miramichi Pulp and Paper Inc.
5. Kent	Atlantic Waferboard Inc.
6. Queens-Charlotte	J.D. Irving Limited
7. Fundy	Rothesay Paper Limited
8. York	Ste. Anne-Nackwic Pulp & Paper Co. Ltd.
9. Carleton	Juniper Lumber Company Limited
10. Restigouche-Tobique	Fraser Inc.

A map included in Appendix A shows the Crown land licenses.

As noted above, the licensees, together with their respective sub-licensees, manage the Provincial Crown lands in the Province.

A major aspect of the management process is the harvesting of forest products. These same companies also own the majority of the large freehold lands in the Province. Together they control approximately 66 percent of the Province's productive forest lands and the harvesting therefrom.

Most of the forest lands in New Brunswick are accessible. A very small percentage is too steep to harvest and the volume on this land is insignificant. The steeper terrain often contains high quality sawlogs and, in most instances, trail preparation for the skidders allows this volume to be harvested at reasonable costs.

The harvesting methods vary from license to license. Upwards of eighty percent of the harvesting volume is felled manually using chainsaws. In licenses 2, 5, 8 and 9 all felling is done in this manner.

Delimbing is more mechanized; with only 51 percent of the commercial volume being delimbed manually at the stump while 6 percent is delimbed mechanically at the stump and 43 percent mechanically at roadside.

2.2.2 Marketing Boards

Most of the commercial forest products harvested from the non-industrial woodlots of New Brunswick are sold through the seven forest products marketing boards. These are listed below, and are also shown on the map included as Figure 2, Appendix A.

Forest Products Marketing Boards in New Brunswick

1. Carleton-Victoria
2. Madawaska
3. North Shore
4. Northumberland
5. Southeast New Brunswick
6. Southern New Brunswick
7. York-Sunbury-Charlotte

Since 1983, all non-industrial woodlot owners have been under the jurisdiction of one of the marketing boards. The Forest Products Commission monitors the operation of the marketing boards.

The Commission is a government-appointed agency with membership drawn from industry, woodlot owners and the general public. The boards are authorized to negotiate volumes, prices, delivery schedules and other matters related to marketing wood from non-industrial woodlots.

The Forest Products Commission maintains a record of all wood contracted for, and delivered by each of the marketing boards.

The Department of Natural Resources and Energy (D.N.R.E.) maintains a "Timber Utilization Survey". This record is made by Departmental staff interviewing representatives from the pulp and paper mills, fibreboard, plywood plants and the sawmills consuming more than 500 m^3 (solid) roundwood.

The Timber Utilization Survey has been done in the past with reference to D.N.R.E. Forest Management Regions. In the future, the Crown Licence harvest figures will be sorted by Licence,

with small freehold figures sorted by Marketing Board, and Large Freehold by individual owner. In the interest of subdividing total wood production on a regional basis, the Licence boundaries were selected for the puropses of this study as the most appropriate single regional reference available.

Licence boundaries are recognized as an imperfect reference due to overlapping jurisdictions, but they do give an approximate regional reference for individual contractors and processing facilities contacted during the course of this investigation.

2.3 Summary of Roundwood Production by License

Personal interviews were held with representatives of each licensee in the Province and with a spokesman for each Regional Resource Office of D.N.R.E.

These interviews were to obtain an overview of forest operations in each region and to gather data on any wood residue currently being utilized.

The annual harvest volume was discussed with each licensee including the method of harvesting. Particular emphasis was placed on where the resultant slash is left. Any unused or underutilized species were noted. Any known uses of harvest residue were recorded.

Each Forest Products Marketing Board in the Province was visited and discussions were held to determine details of forest operations under the Board's jurisdiction. An attempt was made to determine the volume of wood harvested by each harvesting method, and larger contractors (producing 1000 or more cords per year) were identified.

Attempts were made to contact the identified contractors by telephone. Most of those reached were very helpful and supportive of the idea of using forest residue for productive purposes. Others were evasive and gave obvious underestimations of the wood they actually harvested.

Based on all the interviews and records available from the D.N.R.E. and the marketing boards, two tables were compiled as follows:

Table 2.3.1 - Summary of All Wood Harvested in N.B. (1986-1987) by Ownership

Table 2.3.2 - Summary of All Wood Harvested in N.B. (1986-1987) by License Boundary

TABLE 2.3.1

SUMMARY OF ALL WOOD HARVESTED IN N.B. (1986-1987) BY OWNERSHIP
(Based on DNRE Utilization Records)
(m^3 Solid)

	Residue Location After Harvesting*			
	Full** Tree Chips	Stump	Roadside	Total
Crown		2,468,031	1,777,484	4,245,515
Marketing Boards***		1,992,375		1,992,375
Four Largest Industrial Freehold	334,033	419,216	1,717,530	2,470,779
Other Freehold	72,412	591,236		663,648
Federal Lands	31,863	55,271		87,134
Total	438,308	5,526,129	3,495,014	9,459,451

* Does not include fuel wood

** More than 95 percent of chip volume reported is for pulp mill furnish

***Records by Marketing Boards

TABLE 2.3.2

SUMMARY OF ALL ROUNDWOOD HARVESTED IN N.B. (1986-1987)
BY LICENSE BOUNDARY* (m^3)

(Based on DNRE Utilization Records and Marketing Board Information)

	Residue Location After Harvesting		
Licensee	Stump	Roadside	Total
1	470,918	101,643	572,561
2	524,482		524,482
3	293,878	181,171	475,049
4	524,677	175,197	699,874
5	108,083		108,083
6	537,764	782,035	1,319,799
7	961,761	606,399	1,568,160
8	660,013	196,233	856,246
9	489,730		489,730
10	954,823	1,452,336	2,407,159
Total	5,526,129	3,495,014	9,021,143

*Note that reported volumes from freehold lands within the overall Licence Boundaries are included in these figures.

2.4 Missing Volume

The previous tables have been completed using the best available information. There are, however, some notable omissions.

The largest is the fuelwood estimate. Approximately 53,000 m^3 (solid) was reportedly cut from Crown lands under the Crown fuelwood program. An additional 18,560 m^3 (solid) of fuelwood was harvested under licensee, sub-licensee operations and 103,283 m^3 (solid) was harvested from Crown land under special permits in 1986-87. The best estimate of the total domestic fuelwood consumed in New Brunswick is 350,000 m^3 (solid).

The following forest products are also part of the missing volume:

(1) Nonreported wood going to the USA;
(2) Purchased sawlogs by small sawmills;
(3) Custom sawing for farm and personal use;
(4) Fishing industry (weir stakes, etc.); and
(5) Fencing for farm use.

The total missing volume is estimated to be less than 5 percent of the total harvest.

2.5 Total Residue Production from the Forest

The following tables show the estimates of residue that could be available from: (a) the salvage of slash from the harvesting of commercial roundwood in the Province; and (b) the harvest of presently unmarketable "surplus" stands.

Note that higher value competing uses for the wood identified as "surplus" in these tables may be developed in the foreseeable future. A portion of these "surplus" stands would then become marketable, and unavailable for use as fuel wood.

Two such competing uses that are presently being considered include hardwood pulp production and waferboard production.

TABLE 2.5.1

SUMMARY OF ESTIMATED WOOD RESIDUES GENERATED BY HARVESTING IN N.B.

	Residue Location		
License	BD Tonnes Stump	BD Tonnes Roadside	BD Tonnes Total
1	141,275	30,493	171,768
2	157,345	--	157,345
3	88,163	54,351	142,514
4	157,403	52,559	209,962
5	32,425	--	32,425
6	161,329	234,610	395,939
7	288,528	181,920	470,448
8	198,003	58,870	256,873
9	146,919	--	146,919
10	286,447	435,700	722,147
Total	1,657,837	1,048,503	2,706,340

(Based on the assumption that 1 m^3 of roundwood harvested yields 0.3 BDT of residue. See Appendix B).

TABLE 2.5.2
WOOD FUEL POTENTIAL FROM SURPLUS STANDS
(Based on Allowable Cut)
1987

SOFTWOOD

	AAC (m^3)	Actual Harvest (m^3)	Surplus (Deficit m^3)	Wood Fuel Potential BD Tonnes (1)
Crown	3,825,000	3,765,682	59,318	43,302
Marketing Board (2)	1,640,930	1,905,478	(264,548)	
Large Industrial Freehold	1,260,000	1,887,760	(627,760)	
Federal Lands (3)	90,350	41,616	48,734	35,576
Total	6,816,280	7,600,536		78,878

Notes:

(1) Based on the assumption that 1 m^3 (solid) of stemwood yields 0.73 BD tonnes whole tree chips. See Appendix B.

(2) Includes Other Freehold as shown in previous tables.

(3) Actual harvest levels supplied by Colin Rayworth, Canadian Forestry Service.

TABLE 2.5.3
WOOD FUEL POTENTIAL FROM SURPLUS STANDS
(Based on Allowable Cut)
1987

HARDWOOD

	AAC (m^3)	Actual Harvest (m^3)	Surplus (Deficit m^3)	Wood Fuel Potential BD Tonnes (1)
Crown	1,801,000	479,833	1,321,167	1,149,415
Marketing Board (2)	1,209,000	750,545	458,455	398,856
Large Industrial Freehold	845,000	583,019	261,981	227,924
Federal Lands (3)	48,450	45,518	2,932	2,551
Total	3,903,450	1,858,915		1,778,746

Notes:

(1) Based on the assumption that 1 m^3 (solid) of stemwood yields 0.87 BD tonnes whole tree chips. See Appendix B.

(2) Includes Other Freehold as shown in previous tables.

(3) Actual harvest levels supplied by Colin Rayworth, Canadian Forestry Service.

2.6 Catalogue of Potential Forest Residue Producers

A great many of the major woods contractors identified during the study were contacted and interviewed. A catalogue of these contractors and a summary of the interviews is included with the computer program which forms a part of this study.

3.0 SOURCES OF RESIDUE FROM WOOD PROCESSING OPERATIONS IN NEW BRUNSWICK

All operations that process roundwood produce some form of residue as a by-product and these by-products may or may not be further utilized to form a saleable product. As an example, a sawmill produces lumber as its product and generates chips, shavings, sawdust and bark as by-products. The chips may then be forwarded to a pulp mill and used to produce paper, and shavings may be used as raw material for flakeboard manufacture, leaving the remaining material as waste. Much of this waste residue is now being used as fuel to generate energy.

The present study attempted to identify the total quantity of residues other than pulp grade chips and shavings for flakeboard manufacture produced through the processing of roundwood in the Province.

Lists of wood processors in the Province were obtained from the Department of Commerce and Technology (D.C.T.) and also from the D.N.R.E. A total of 127 sawmills were identified as potential sources of a significant quantity of residue. (In general, mills that produce less than 100,000 board feet of product a year were not considered due to the small quantity of residue generated, and the fact that these sawmills may only operate one or two months of the year.)

A telephone questionnaire was drawn up to record information such as the company name and its location, a contact person and telephone number, the types and quantities of residues produced and the present use of these residues.

Early in the survey, it became apparent that many "gaps" in the desired information would be present, especially in the case of sawmills sawing one million board feet or less a year, because

the owners did not really know how much residue they produced. In other cases, no information was forthcoming from the interviewee.

During the course of the study, it was learned that the D.N.R.E. interviews sawmill owners in the Province that use in excess of 500 m^3 (solid) of roundwood per year, for their Timber Utilization Reports. As part of this process, information is also collected on the quantity of wood residue produced. This reporting is not complete, however, and records for many sawmills show no residue produced. By cross referencing with the large consumers of residue who report where their residue is purchased, much of this information could be obtained. A further problem with reported data became apparent when checking reported residue production against roundwood consumed. Sawmills are generally reporting what they sell and not their total production of residue.

With these problems in mind, it was decided that some form of verification system was required in order to produce reliable estimates. Sawmills were loosely grouped by equipment type, production and species utilized and an average residue production level was derived from sources considered to be reliable, as a check against the reported figures.

An important aspect of any residue use for energy production is the moisture content of the material to be burned. Discussions with producers of residue, who are also users, revealed that moisture content of residues varies greatly, depending on the type of residue and also the time of year. Sawmill residues that have been left in the open during the summer may have a moisture content in the vicinity of 30 percent (wet basis) whereas bark, fresh from the debarker at pulp mills, may be in

the 60-70 percent range. Due to this variability, it was decided, for the purposes of this study, that all conversions from green to a bone dry basis would be based on the assumption of a 50 percent moisture content (wet basis).

This figure is borne out by the Northeast Energy Services analysis of moisture content for all fuel burned at the University of New Brunswick heating plant. Reported moisture contents range from the high of over 60 percent to a low of 30 percent with a yearly average of approximately 50 percent wet basis.

The engineering units in which the quantity of residue production was reported also varied widely. These units included green tonnes, dry tonnes, green tons, dry tons, and m^3 equivalent. In order to have a common basis for comparison, it was decided that all units would be converted to a dry tonne with the conversion factors used as follows:

1 dry tonne = 2 green tonnes
1 dry tonne = 1.1 dry tons
1 m^3 equivalent = 1.14 dry tons

The m^3 equivalent is only used by Miramichi Pulp and Paper and is their method of dealing with the wide variation in moisture content of wood residues.

This process yielded what are considered to be reliable estimates of residue production for 80 of the 127 sawmills identified and these sawmills represent approximately 95 percent of the total processing residue production as shown in the following table.

TABLE 3.1

TOTAL PROCESSING RESIDUE PRODUCTION FOR NEW BRUNSWICK (BD TONNES PER ANNUM)

LICENSE	*	HOG	SAWDUST	SHAVINGS	BARK	SLABS	TOTAL
UPSALQUITCH	1	65,000	4,664	3,110	4,186	0	76,960
NEPISIGUIT	2	41,000	10,556	7,038	9,474	0	68,068
LOWER MIRAMICHI	3	70,827	7,969	5,216	146,221		231,413
UPPER MIRAMICHI	4	0	4,500		5,400		9,900
KENT	5		100			480	580
QUEENS-CHARLOTTE	6	16,300	56,620	7,122	50,288	235	130,565
FUNDY	7	93,455	25,769	14,806	27,414	4,870	166,314
YORK	8	46,300	18,045	8,387	15,264	4,205	92,201
CARLETON	9	1,100	33,165	10,497	15,419	2,010	62,191
RESTIGOUCHE-TOBIQUE	10	30,498	49,026	22,052	42,563	24,090	168,229
GRAND TOTALS		**364,480**	**210,414**	**78,228**	**316,229**	**37,070**	**1,006,421**

NOTE: Commercial by-products such as pulp grade chips and flakeboard material not included in this table.

An important part of the survey was to determine the present means of disposition of the sawmill residues. The primary reported use was energy production with a small amount sold or given to farmers for animal litter. Approximately 85 percent of total residue production was reported as being used at present. A detailed summary of reported residue production by individual sawmill is included with the computer program which forms a part of this study.

4.0 CONSUMERS OF RESIDUE IN NEW BRUNSWICK

4.1 Data Collection Procedure

A telephone questionnaire was again used as a means to collect the desired information as quickly as possible.

Many of the larger residue consumers were well known prior to commencing the survey, but some additional sites were identified in conversations with sawmill managers and trucking firms who supply and transport residues to these sites.

Each consumer was classified as to the end use of the material according to the following classification categories:

(a) Process Steam
(b) Dry Kilns
(c) Institutional Heat
(d) Greenhouse Heat
(e) Commercial Heat
(f) Direct Product

The type of residue used at these sites was also identified as falling in one or more of the following categories:

(a) Sawdust
(b) Shavings
(c) Bark
(d) Hog Fuel
(e) Whole Chips

4.2 Discussion of Findings

As expected, the pulp and paper mills accounted for the vast majority of residue consumed within the Province.

The total consumption in 1987 is estimated as 926,097 BD tonnes including 70,000 BDT of shavings for flakeboard manufacture, with the eight major mills accounting for 749,000 BD tonnes.

The flakeboard mill at Milltown is a large user of sawmill shavings as a raw material for its particleboard product. They plan to expand their consumption of N.B. residues to approximately 85,000 BD tonnes within the coming year.

An overall summary of residue consumed by type of material within the Province is presented in Table 4.2. This summarizes all the individual consumer data that is contained in the computer program which forms a part of this report.

TABLE 4.2

REPORTED CONSUMPTION OF N.B. RESIDUES FOR ENERGY INSIDE NEW BRUNSWICK

Residue Type	Total Consumed (B.D. Tonnes/Yr)	Averaged Price ($/B.D. Tonne)
Sawdust	21 225	$28.93
Shavings	1 500	33.00
Bark	0	0.00
Hog Fuel	830 547	21.84
Chips	2 825	30.50
	856 097	

5.0 CONSUMERS OF N. B. RESIDUE OUTSIDE NEW BRUNSWICK

5.1 Data Collection

The same procedure as used in Section 4 was used to collect information on consumers outside New Brunswick.

5.2 General Discussion of Findings

Substantial traffic in New Brunswick residues leaving the Province was identified between N. B. and Quebec, as well as the State of Maine.

The Quebec market for residue consists primarily of three pulp mills in the Gaspe region. The present volume estimated to be purchased by these pulpmills is 67,000 BD tonnes. Some difficulty was encountered in obtaining these figures since there seemed to be a reluctance on the part of the pulpmills to divulge information on residue imported from New Brunswick. Data from truckers was used to cross check the estimates.

The traffic of residue into the State of Maine was found to amount to 72,330 BD tonnes per year. The Georgia Pacific pulpmill at Woodland, Maine has been a major user for a number of years and continues to consume 33,600 BD tonnes per year.

The recent development in Maine of several privately owned wood-burning power stations is having an impact on the market for residue in New Brunswick. This is discussed in more detail in Section 8.

Only one regular consumer of N.B. residue was identified in Nova Scotia, and none were identified in Prince Edward Island. Again, these findings and some of the background on the market conditions in Nova Scotia and P.E.I. are discussed more fully in Section 8.0.

A catalogue of all identified consumers of N.B. residue outside the Province is included on the computer program which forms a part of this report.

6.0 DELIVERED COSTS OF WOOD RESIDUES

6.1 General Discussion of the Model

In this section the input cost components and assumptions underlying the model for calculating the delivered cost of wood residue are summarized. Figure 6.1 presents the flow chart of the computer model for input, analysis and output system components. A guide to the model operations is presented in Appendix D. All cost parameters are inflated to the specified year of analysis by a general average annual inflation rate of 5 percent per annum or as otherwise specified by the user. The truck fuel prices are likewise inflated to a user-specified price at the year of analysis.

In using the cost model it is important to recognize that, because of limited competition in this market, actual quoted prices for a specific application may vary considerably from the calculated theoretical "costs".

The model permits the user the choice of residue source, each of which has an associated material cost at the source. It also allows selection of the composition of the residue material, as appropriate, from the selected source with associated processing costs given in the model. The model then requests the haulage distance of the residue to its market and the user's choice of transport mode system. From these input parameter values and choice sets, the model will produce an estimate of the delivered costs per bone dry tonne of the specified residue. A cost summary of the material, processing and transport cost components is reported for the stated year of analysis. All costs have been expressed in bone dry tonnes throughout the model.

The following paragraphs outline the model structure and the assumptions used in the computer model systems and component costs.

6.2 Wood Residue Resources, Materials and Markets

Wood residues can be acquired from three sources:

1. sawmills;
2. logging operations; and
3. dedicated wood fuel stands.

End uses and markets for wood residues are:

1. energy; and
2. manufactured products.

6.2.1 Sawmill Residues

Sawmills produce as by-products three types of material which can be used as fuel:

1. mixture of bark, sawdust and shavings (hog fuel);
2. slabs or chips; and
3. sawdust.

These materials may be hogged and screened at the source sawmill or hauled to their destination as is, and processed for fuel consumption. Other sawmill by-products are sold as they are for various product uses as follows:

1. shavings - for flakeboard;
2. sawdust or chips - for pulp;
3. bark - for nursery mulch;
4. shavings and sawdust - for livestock bedding;
5. slabs for residential firewood.

6.2.2 Pulp Mill Residues

Pulp mills produce two wood by-products that can be used exclusively for energy:

1. bark; and
2. pulp sludge (generally too wet for sustained combustion).

This material is always used by the pulpmill that produced it, so the cost is of academic interest only.

The bark is processed on site at the pulpmill. Purchased hog fuel is delivered, from sawmills, as is, to the pulp mill for processing and consumption.

6.2.3 Logging Operations

Where wood residues from logging operations are to be used as fuel, they are processed in the forest by chipping or hogging. Fuel chips can be produced from seven different logging operations and/or processing techniques:

1. clear cut operations with residue broadcast at stump;
2. clear cut operations with residue trail cut at stump;
3. Clear cut operations with full tree chipping at roadside;
4. cutover operations clearing residuals;
5. selective harvesting operations;
6. precommercial thinning operations; and
7. salvage operations.

6.2.4 Dedicated Fuel Wood Stands

Wood fuel can be produced by on-site chipping at timber stands which are not otherwise marketable. These include:

1. submarginal stands; and
2. surplus species stands.

6.3 Wood Residue Material and Processing Costs

6.3.1 Sawmill Residue

The costs for sawmill residues are relatively easy to develop as there is a defined market for these materials. There are four major types of sawmill residue as follows:

1. Hog fuel - The term generally refers to a mixture of materials that includes sawdust, shavings and bark in varying proportions. Discussions with sawmill spokesmen indicated that a typical cost for this unprocessed material is presently $9 per dry tonne loaded on a van at the sawmill yard. Typical moisture contents are 50 percent on a wet basis.

2. Slabs from sawmills - There is a demand throughout the Province for a small quantity of sawmill slabs to be used for residential firewood. It is difficult to develop an organized market for this material, because they are produced only at small sawmill operations which are not equipped with chippers to process slabs into pulp chips. Therefore, slabs are available only in small quantities at scattered locations. Prices for this material vary greatly depending on whether slabs are hardwood or softwood and the proximity of the sawmill to a market. Prices vary from a

high of $25 per cord, for hardwood slabs at the mill, to 0 for softwood slabs (i.e., they are given away). An average cost of $12 per dry tonne may be considered typical.

Most larger sawmills feed softwood slabs and edgings into chippers which produce a high quality chip that is sold to pulp mills as feed stock at a typical delivered price of $50 per dry tonne.

3. Sawdust - Energy systems have been developed to use only sawdust and it may also be used as is in a large system. A typical loaded cost of $4 per dry tonne at the sawmill yard was reported.

6.3.2 Harvest Residues

Harvest residues are those materials that are left behind after a logging operation and the term includes limbs, tops, and residual trees. The as-found location of these residues has a great effect on the cost of processing for energy purposes. In the Province of New Brunswick, logging operations generally are carried out in one of three ways:

1) Trail cut - In this method of harvesting, trees are felled, delimbed, bucked and piled for forwarding with the use of a porter. The residue is generally left in windrows but it also may be scattered.

2) Tree length - Trees are felled, delimbed and topped at the stump and then forwarded to roadside with a skidder, for further processing or trucking. The residue is "broadcast" over the harvest site.

3) Whole tree - In this method, the only operation occurring in the woods is the felling of the trees, and then the whole tree is moved to roadside, either by skidders or forwarders, for the delimbing and topping operations. The majority of residue produced by this operation is within 20 metres of the road.

Although methods 1 and 2 are different types of operations, the residue is still left in the woods and for practical purposes, spread over the whole harvest site and will be considered the same for estimating costs of production.

The costs developed in this section refer only to limbs, tops, etc., and to small quantities of residual trees. Areas with large quantities of standing residuals are considered under whole tree chips.

As discussed above, these residues are left either at roadside or in the woods; therefore, two separate costs had to be developed. It should be noted that as these residues are a by-product of the harvesting operation, no stumpage or royalty fee has been added to the costs shown.

1) Residue Located in the Woods

Many studies and trials have been carried out in recent years involving the collection and processing of residues left at the stump. A recent study by the Forest Engineering Research Institute of Canada (FERIC) (3) evaluated the Bruks chipper system. Trials were carried out in Sweden, New Brunswick and Newfoundland on the Bruks 1000 series chipper and indicated costs for chipping ranging from $18.23 to $29.72 per B.D. tonne. A further series of trials on a prototype 800 series Bruks chipper were carried out in Nova Scotia, Prince Edward Island

and Newfoundland and indicated chipping costs of $16.96 to $33.05 per B.D. tonne. (There are now at least three of the 800 series working in Canada.) Although none of these trials are directly comparable due to different conditions and methods of calculations, the reports do give an indication of what cost range may be expected for this type of operation.

Stora Forest Industries, in Nova Scotia, and Miramichi Pulp and Paper (formerly Boise Cascade) in New Brunswick have both been using the 1000 series Bruks Chipper for a number of years. Both companies have reported costs per green tonne loaded on a van in the $26 range ($52/B.D. tonne). These costs are considered to be very reliable due to the length of time involved in these operations and also because they are based on ongoing operations by private contractors.

FERIC has developed and tested a prototype machine called the "RECUFOR" which was designed to collect and process logging residues in the woods. Although its performance indicated that this machine was technically feasible, its production costs were high. The machine was very heavy and production levels low (2.4 B.D. tonnes/M.H.).

Two other forms of residue may be located in the woods:

i) Branches and tops left after a selective harvest in which only a portion of the total volume in a stand is removed; and

ii) Trees that are felled during a pre-commercial thinning operation.

These two cases are considered to be essentially the same, as the residue is intertwined with the standing trees of the remaining stand and, as such, are extremely difficult to access

in an economic manner. Large equipment is definitely out of the question due to the danger of damaging the remaining trees. Therefore, this material would have to be collected either with small, agile equipment or by hand. Either method would yield very low production levels due to the small loads involved and costs would be high. One test operation was performed by students and costs were in the order of $90 per B.D. tonne. A commercial operation would certainly be able to increase productivity and reduce this cost, and this type of biomass harvesting is being done in the U.S. on a cost-effective basis. The silvicultural benefit to remaining growth should be evaluated and included in the analysis of this type of operation, but it is, at present, considered to be the most expensive source of residue examined.

2) Residue Located at Roadside

Harvesting residues located at roadside are becoming more prevalent in the Province as the forest companies move further towards mechanized harvesting. As these residues are already at roadside, the only cost involved is for processing. One of the biggest problems associated with this material is dirt contamination and the resulting wear on chipper knives. A further problem can be feeding material to the chipper fast enough to achieve high production levels.

The only commercial method for processing these residues, at the present time, is the Bruks chipper system. As mentioned in the previous section, these machines incur costs of $16.96 to $33.05 per B.D. tonne [3] depending on the types of residues being processed and their locations (i.e., in the woods or roadside). Almost all of these studies refer to processing "at the stump" mainly because the majority of harvesting in the Atlantic Region is still done in this manner and, if the site can be cleared,

there is a resultant saving on subsequent silvicultural work in that the site does not require additional preparation. The Boise-Cascade Study [4] indicated that production could, under test conditions, be almost 3 times higher when chipping at roadside versus at the stump due to the elimination of travel to dump the chips. This would not, of course, mean that commercial processing costs would necessarily be lower by this factor. For instance, if whole trees are skidded to roadside and thus become heavily dirt laden at certain times of the year, the production and costs could suffer due to increased knife wear. However, with the use of feller forwarders, much of this problem is eliminated and this problem may not be serious. In consideration of available data and from discussions with forest contractors, it appears that with experience, it should be possible to approach a production cost of $18.50 per dry tonne (loaded in van) for this material.

FERIC has carried out developmental work in this area and a prototype called the "Logging Residue Processor" has been built and tested. During these tests, this system achieved costs as low as $10.56 per green tonne and it is projected that it is possible to achieve a cost of $5.30 per green tonne ($10.60/B.D. tonne) loaded in vans. For the purposes of this study, however, it was decided to use a price which reflects commercially available equipment and procedures.

3) Harvesting Whole Tree Chips

The harvesting of whole tree chips is much more developed than residue harvesting and has been ongoing on a commercial basis for many years. In New Brunswick, both Valley Forest Products and Georgia Pacific Corporation utilize whole tree-hardwood chips to furnish their pulp mills. There are also several

private contractors in the Province who own chippers. Discussions with these companies, marketing boards and private contractors revealed that a cost of $13 per green ton loaded into vans is considered reasonable if stumpage and roads are not considered. This would translate to approximately $28.60 per B.D. tonne.

Whole tree chips may be obtained from such sources as:

i) Cutover residuals - In many cases, a mixed wood stand may be harvested only for its softwood component due to local market conditions. The remaining stand may still contain a high enough value to be deemed operable.

ii) Salvage stands - Insects or fire may render stands unsuitable for a saleable product, but the timber may be quite acceptable as a fuel.

iii) Sub-marginal stands - These stands are not economically feasible to harvest at the present time, possibly due to low values, poor species mix, etc., but if all material is removed, they may be economically attractive as an energy source.

iv) Surplus stands - Hardwood stands form the bulk of surplus stands, although there may be softwood stands composed of cedar or very poor quality white pine, for which there are no markets at the present time. If an energy market existed it might be better to utilize these stands for that purpose than to see them decline due to overmaturing and lose all worth.

For the purposes of this study, all of the foregoing sources of residue are considered to have comparable costs if all material is brought to roadside as whole trees and then processed.

6.4 Wood Residue Transport Systems and Costs

To determine the delivery costs of the processed and/or unprocessed wood residues to their respective consumer markets, a range of appropriate transport systems have been provided in the computer model. Each system's unit transport costs have been developed for a typical set of operating conditions and given as a function of the particular haulage distnce. The resulting vehicle fixed and operating costs per tonne are added to the loading and unloading site costs per tonne for a total transport cost per tonne. This format permits transport cost analyses of specific wood residue movements from source to markets by the user's choice of appropriate transport mode.

The transport mode systems have been selected to provide suitable transport alternatives for all aforementioned wood residue materials and markets. They are:

1. tractor-trailer flatbed system;
2. tractor-trailer fixed bottom van system;
3. tractor-trailer live bottom van system;
4. tandem truck container trailers system;
5. straight tandem axle truck;
6. straight single axle truck; and
7. tug-barge system.

Selection of the appropriate transport modal system option(s) for each given material haulage operation requires identification of the assumed "typical" transport operations most suited to the case at hand. The assumptions and input costs underlying the truck transport systems costs are summarized in Table 6.1. These systems have generally been designed for large scale operations, except the straight trucks.

The cost per km of each truck transport system was determined using the Transport Canada Operating Costs of Trucks in Canada, 1986 truck cost model for each trucking mode system. Costs are categorized by fixed and variable and include:

Fixed Costs	Variable Costs
Equipment depreciation (5 yrs)	Driver wage
Licences	Fuel
Insurance	Repairs
Administration	Cleaning
10% profit margin	Replacement parts
	Tires

All fixed and variable costs have been calculated based upon the average costs in the Maritimes, except equipment and licence costs, which were determined specifically from New Brunswick equipment dealers and government. The loading and unloading costs per tonne were based upon capitalization of any additional equipment requirements (e.g., fixed bottom chip van dumpers, loaders, etc.) at the sources and/or destinations and a manpower cost of $10.00 per hour.

The tug-barge transport system costs were based upon a typical 100-120 km haul of a 1800 tonne payload barge at 80 round trips per year. The total annualized capital costs were estimated at $93,800, operating costs at $450,000 and loading and unloading at $105,000.

7.0 EVALUATION OF THE ENERGY CONTENT OF WOOD RESIDUES

7.1 Combustion Chemistry

For the purpose of analyzing its combustion properties, wood is generally regarded as a simple compound of carbon, hydrogen, oxygen, nitrogen and many trace elements.

The carbon and hydrogen fractions combine with oxygen in the air and within the wood itself to produce CO_2 and H_2O as combustion products.

The energy released from the production of CO_2 and H_2O is generally referred to as the higher heating value or gross heat of combustion. This value is surprisingly similar for most species of wood at a typical value of 8500 British thermal units (BTU) per bone dry pound (BD lb). In SI units, this is approximately 20,089 Mj/BD tonne. Virtually all species fall in a range from 8 to 9000 BTU/BD lb.

This higher heating value is not attainable in a real combustion process for two reasons.

First, wood fuel always contains moisture as free water. Thus each kg of fuel will consist, in part, of water that contributes nothing to heating value. On the contrary, the free water must be raised to a temperature equal to the flash point of the wood to permit wood combustion to take place. That is, the water must be vaporized and driven off, leaving bone dry fuel.

Since the heat of vaporization of water is approximately 1050 BTU/lb (2481 kj/kg) (when referenced to wood at room temperature), a substantial amount of heat from the combustion process

will be absorbed in vaporizing the free water in the wood. This heat cannot usually be reclaimed since it would require the condensation of steam in the flue gas, which is generally impractical for a number of reasons.

The second source of heat loss from the theoretical heating value is the creation of additional water through the combustion of hydrogen in the wood. Most woods contain 5 to 7 percent hydrogen by bone dry weight, and the combustion reaction proceeds as follows.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Atomic mass	4	32	36

Comparison of the atomic masses show that the ratio between the weight of hydrogen present to the weight of water produced in combustion is 4:36 or 1:9. Thus a typical wood containing 6 percent hydrogen by weight BD will produce water equal to 54 percent of the BD weight of fuel during the combustion process. This water consumes additional heat from the theoretical combustion reaction as it is vaporized.

The recoverable or usable heat from wood combustion is generally referenced as the lower heating value. It is simply the higher heating value less allowances for the vaporization of free water in the fuel, and the water produced as a combustion product.

Most species of wood have higher heating values in the range of 8 to 9000 BTU/BD lb (18,900 to 21,250 kj/kg). The middle of this range is commonly accepted as appropriate for most softwood species.

To summarize: lower heating value = higher heating value (kj/kg)
- (hydrogen content x 9 x heat of vaporization)
- (free water content x heat of vaporization).

To facilitate a quick and accurate assessment of lower heating values for various species of wood using the computer program, higher heating values and hydrogen contents for several common species have been entered as data to the program. The user can then calculate lower heating value as a function of moisture content by selecting the species and moisture content.

The calculations done by the computer are based on the analysis of this section.

It is noteworthy that the reduction of free water in wood fuel will improve not just the lower heating value of the fuel, but will also improve the recovery of usable heat by the furnace and boiler system used to convert the heat of combustion to steam or hot water.

This is because of the reduction of mass flow in the flue gas stream that results from the elimination of excess water.

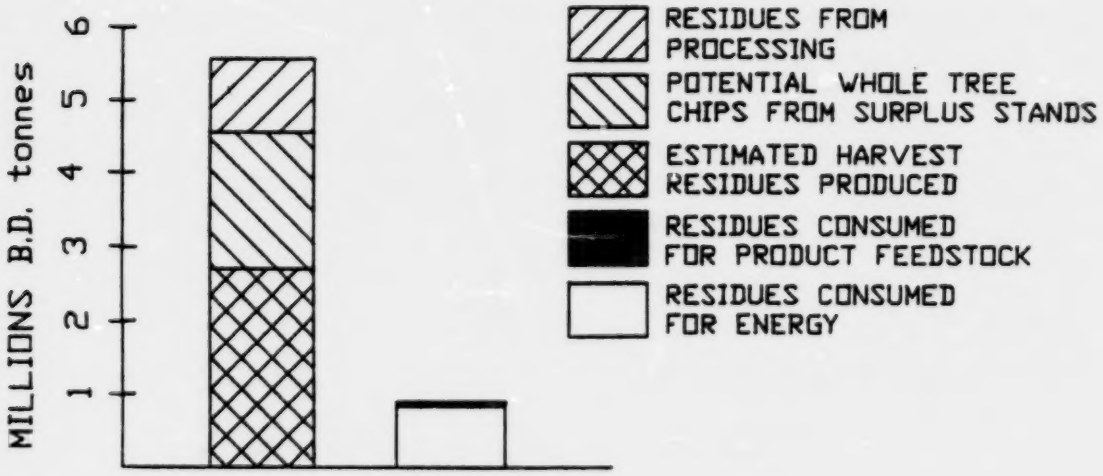
The reduction in mass flow results in better boiler efficiency due to the slower velocity of flue gases through the recovery section of the boiler.

This means that a dryer fuel burned in a given boiler system will give considerably more steam production than would be indicated by the improved lower heating value of the fuel.

8.0 DEVELOPMENT OF THE USE OF N. B. WOOD RESIDUES IN NEW BRUNSWICK AND ELSEWHERE

8.1 New Brunswick

The survey showed a total consumption of New Brunswick residues of approximately 927,000 BD tonnes at the present time. This compares with the estimated theoretical total of actual production and potential production (including harvesting residues and surplus stands) of 5,564,763 tonnes in 1987. Development of silvicultural thinning programs could increase potential residue production beyond even this level. Residue removal of more than 3 BD tonnes per hectare on a 10-year rotation have been reported in the U.S.A. (22)



Potential Supply and Present Consumption of N.B. Residues

Figure 8.1

It is evident from these figures that a tremendous quantity of wood residue is potentially available for utilization.

The development of residue use within the Province began accelerating in the early 1960s with expansion of some of the then-existing pulpmills to burn more wood, and the construction of a flakeboard mill at Milltown.

The flakeboard plant makes use of shavings from area sawmills as a raw material for the manufacture of a high density board product used in the manufacture of furniture. Over the years since its establishment, this plant has expanded to the point where it now consumes 70,000 BD tonnes of New Brunswick residues, with immediate plans to increase by an additional 15,000 BD tonnes.

In 1962 the present NBIP Forest Products Inc. pulp and paper mill in Dalhousie converted a coal-burning unit to burn wood fuel with a capacity of 14,000 MW and a typical annual consumption of 45,500 BD tonnes.

Prior to 1970, pulpmills were established at Newcastle and Nackawic which were designed to burn the residue produced in their operations. Overall production and consumption thus rose at the same time.

In 1971 the Airscrew Weyrock (now Atlantic Waferboard) particleboard plant was established at Chatham. It used a wood burning unit to provide heat for the hot ponds. In 1979 this plant added a wood burning furnace to supply heat for its dryers. This burner replaced oil firing equipment and brought the mill's consumption up to approximately 37,000 BDT per year.

After 1973, interest in wood residue as a fuel expanded beyond the forest industry.

Most institutional heating plants had converted to oil from coal or wood shortly after World War II. One notable exception was the former St. Louis College near Edmundston which converted their coal burning unit to fire sawdust only, and have continued to do so ever since.

One of the earliest institutional conversions which occurred after 1973 was the 1000 kW unit installed at the Maritime Forest Ranger School in Fredericton in 1977. This unit burned chips made from the slabs produced at a small training sawmill associated with the school.

The Madawaska Regional Correctional Centre installed a wood burning boiler plant in 1981. Since that time, several hospitals including two new regional hospitals, have installed wood-burning boiler units.

The largest institutional unit in the Maritimes is the University of New Brunswick Central Heating Plant installation with a capacity of 12 MW. It was commissioned in 1984 and uses approximately 16,000 BDT of fuel per year.

All of these institutions use sawmill residues as fuel.

Since 1980, the large pulpmills have installed substantial new wood-burning capacity.

NBIP added a 59 Mw unit in 1982 which boosted their consumption by some 140,000 BDT per year.

The Consolidated Bathurst pulpmill at Bathurst installed their first wood-burning boiler in 1984 and now consume approximately 82,000 BDT per year.

The Fraser Company pulpmill at Atholville began burning wood residue in 1983 and consume some 69,000 BD tonnes per year.

The Repap Miramichi pulpmill are planning to increase the production and the fuel consumption of their existing plant by some 50,000 BDT per year in the near future.

The Repap organization is already engaged in harvesting of forest residues to, supplement internal production and purchases of sawmill residues.

Irving Pulp and Paper Limited of Saint John installed a 90 MW wood-fired unit in 1985 which consumes some 218,000 BD tonnes of residue per year. A large part of this is residue from Irving-owned sawmills, and the Lake Utopia Pulp and Paper Mill which is also part of the Irving interests.

It is evident from this discussion that the use of residue as fuel has increased dramatically during this decade. At present, however, the trend toward expanded consumption has been stalled by the drop in oil prices since 1984.

No major boiler projects are committed at this time, and several smaller conversions have been shelved until such time as the potential savings on oil costs will justify the necessary investment.

A possible exception would be a proposed gypsum wallboard plant in the McAdam area which could consume as much as 44,000 BDT of residue, beginning in 1989-90.

This decade has seen the establishment of a fledgling prepared fuel industry in the Province. For example, the Devon Lumber Company of Fredericton processes bark, sawdust chips and

shavings into prepared hog fuel for several institutional plants in the Fredericton region. In addition to incremental employment, this operation buys residues from other local sawmills that had previously been landfilled. This results in an improved balance sheet for these sawmill operations and a more competitive lumber industry. Some contractors are already engaged in residue chipping for fuel purposes, but activity is still quite limited in this area.

8.2 Nova Scotia

It was found that comparatively little New Brunswick residue is being transported to Nova Scotia.

Gordon's Greenhouse of Oxford, N. S. was one of the earliest of the small wood burning installations in the Maritimes, and this firm does use approximately 6600 BD tonnes per year of New Brunswick hog fuel.

Nova Scotia has been slower than either Prince Edward Island or New Brunswick to support and encourage wood burning installations in the small industrial and institutional setting, but there is now a commitment by the provincial government to develop a fuel wood industry in that province.

To that end, a small wood burning heating plant was installed at Pugwash in 1986 to provide space heating for an institutional building.

In 1987, the provincial government plans to install an 80 HP unit at the new forest greenhouse project at Musquodoboit.

The private sector in Nova Scotia has been active in developing wood burning projects. Britex Limited installed a 600 HP European boiler in 1985 at their Bridgetown plant.

More recently, Ultra Power Inc. of Fairfax, Virginia has been investigating the possibility of establishing a 20 MW power plant in the Digby area to use locally produced wood fuel. This firm already has installations in the State of Maine and the Province of Newfoundland.

Much of the political impetus for using wood fuel in Nova Scotia is being generated by the Nova Scotia Woodlot Owners and Operators Association, who are particularly interested in forest residue consumption from Nova Scotia woodlots. It is therefore doubtful that New Brunswick residues would be in demand for any plants developed by the provincial government.

However, private developers such as Ultrasystems and others from the industrial sector could generate a significant demand for residue from New Brunswick. Whether or not this actually occurs will depend on the cost of competing fuels and the extent to which government policy favours conversion to wood.

The presence of the offshore gas fields near Nova Scotia could create some competition to wood as a locally produced fuel, but the cost of developing this resource is likely to be high enough that wood residue would prove to be more attractive for those consumers that are large enough to justify a wood burning plant.

8.3 Prince Edward Island

Prince Edward Island was very quick to respond to the energy problems which arose in 1973. Through the establishment of the Institute of Man and Resources and the subsequent PEI Energy

Corporation, the Province has been very active in investigating and applying technology to displace the Island's dependence on imported energy.

PEI is in the unique position among provinces of being totally without conventional energy sources such as coal or hydro-electric power.

During the late seventies and up to the present time, the PEI government has constructed a number of wood burning plants ranging from a 200 kW unit at the Montague Junior High School to a 3500 kW unit at the University of Prince Edward Island. The latter installation is part of a planned district heating system in the Charlottetown area and construction on about 7 km of pipeline in the University area is expected to commence shortly. A second system is already in place in the downtown area.

A large wood burning power plant is projected for the downtown Charlottetown area. This plant would be capable of supplying heat to the downtown core area while generating electric power from locally produced fuel wood.

Such a plant could consume 150,000 BD tonnes of fuel wood per year.

Prince Edward Island's wood energy development has been almost entirely through government initiative, however, and like Nova Scotia, the primary political motivation is to develop the fuel wood industry rather than to save money as an owner of the plant.

Consequently, all of the projects of the PEI Energy Corporation and the government departments or agencies make use of whole tree chips produced on Prince Edward Island. This fuel is more

expensive than the sawmill residues in common use in New Brunswick, and the Energy Corporation has been approached by New Brunswick suppliers with attractive offers to deliver fuel wood to PEI.

It is doubtful that any New Brunswick residue will be used there, however, because of the political considerations.

At present, very little potential exists for private wood energy projects on PEI because of the prevailing high price for whole tree chips. The simple economics of plant capital and operating costs will not justify an owner's investment at the present time.

If the proposed power plant is constructed at Charlottetown, the chip supply network would have to be expanded considerably, and it is likely that economies of scale may combine with increased competition in the marketplace to reduce some chip prices somewhat, although the cost of longer fuel hauls to service this large load may offset any such savings.

If fuel oil prices increase substantially, then private interests may become interested in wood burning and in buying less expensive New Brunswick residues as fuel. The potential impact of such a development on New Brunswick would probably not be significant, since there are relatively few large users of steam on Prince Edward Island.

8.4 Quebec

Quebec has been in a unique position with respect to New Brunswick and the other Maritime Provinces in that it has an abundance of low cost hydroelectric power. With electric power rates among the lowest in North America, there has been little

economic incentive to adopt wood as a low cost energy source for institutional buildings or industrial uses outside of the forest industry. In fact, Hydro Quebec has recently embarked on a program of encouraging large industries to install electric boilers to produce steam from electric power at extremely attractive rates.

The only markets for N.B. residues that were identified were three large pulpmills located within a few miles of the provincial boundary. Details are included with the computer program.

There would seem to be little potential for development of wood-burning power stations in Quebec in the foreseeable future because of the abundance of cheap electric power in this jurisdiction.

8.5 Residential and Commercial Use of Wood Residue Fuels

The use of particulate residue fuels in residential sized furnaces has been the subject of considerable research during the last decade, and some equipment has been made available on a commercial basis, with very little commercial success.

In contrast, stick wood burners such as airtight stoves and combination furnaces have become quite popular due to their relative simplicity and low cost.

It is doubtful that residue fuels such as sawdust and hog fuel will ever be widely used in small scale residential units. The problems of handling, storing, and burning these relatively unprocessed fuels are not compatible with a residential setting. Residue fuel must be handled in bulk quantities from trucks. It typically has a relatively strong odor associated with it, and often harbours various species of spores which can become a problem in a residential environment.

If oil prices were to become extremely high, it is conceivable that a residential market might develop for densified residue fuel or wood pellets.

Pelletized fuel is a dried, processed hog fuel product with very high heating value, and very good handling characteristics. Plants presently exist in Lac Megantic, Quebec and Hearst, Ontario to produce this product under the trade name "Woodex".

Because it is dried, woodex is much less heavy and bulky than wet wood waste for a given heating value, thus reducing storage and transportation costs.

It is still a very expensive fuel, however, and, at present, it appears doubtful that pelletized wood fuel will become widely used in the near future.

8.6 Outlook for the Future

As noted previously, the growth of wood fuel consumption has been extremely rapid during the first half of this decade. With the recession of oil prices over the past two years, this growth trend has slowed considerably.

The outlook for the future depends upon the developments in the oil and gas markets as well as the policies of Federal and Provincial Governments.

If oil prices were to begin rising at a rate which exceeds the general rate of inflation by a significant degree, it would seem likely that consumption of residue would begin to increase as the rate of return on new plants became more attractive. Present indications are that oil prices will climb gradually over

the next three or four years. In the 1990s there is a possibility that a shortfall in domestic oil supply may occur due to the present delays in developing production capability for frontier and offshore oil fields.

The significance of domestic shortfalls will be determined by political and economic developments in the oil exporting nations. An oil shortage may develop, or the present oversupply could persist for a few more years. In the long term (say 20 years), it seems probable that oil prices will be considerably higher than the general rate of inflation, since the depletion of existing reserves will be a major factor by that time.

Comparatively modest increases in present oil prices will not generate the massive buildup of demand for wood fuel which has occurred in this decade, since during the rapid expansion period, oil prices were high and moving higher at a rapid pace. The general expectation was that future economic return on a project would be better than the already acceptable return at that time.

Today, this inflationary psychology has been replaced with a much more conservative view that has been reinforced by several years of stability in energy prices.

At present, it appears that increased demand for wood fuel in New Brunswick due to the economic return on investment will be modest until at least the early 1990s.

Another factor which could have a major impact on residue demand is the political policies of the Federal and Provincial Governments.

As noted previously, the Government of Prince Edward Island has adopted a deliberate policy of support for the development of a residue industry based on the utilization of unmerchantable stands of timber in the form of whole tree chips. The use of this fuel as opposed to imported oil does make sense politically for the following reasons:

(a) Employment is created. Local people with limited work skills can be gainfully employed by this industry.

(b) The Provincial balance of trade is improved. Money previously paid out for foreign oil is retained in the local economy.

(c) This is a highly visible initiative because it is broadly based; most residents are aware of the government's activity in this area.

(d) Wood burning is attractive from an environmental standpoint.

Many energy technologies are under fire from environmental action groups. Combustion of oil and coal produce acidic compounds and carbon dioxide, both of which have harmful effects on the environment. "Acid rain" and the "greenhouse effect" are household phrases associated with the environmental impact of fossil fuel combustion.

Nuclear power has a good record for environmental impact, but suffers from a negative public perception which arises from highly publicized incidents such as Three Mile Island and the recent Chernobyl disaster.

The question of eventual storage of high level nuclear waste is another politically troublesome, though technically manageable, aspect of nuclear power.

In contrast, wood burning in large plants has very little negative environmental impact. Wood contains almost no sulphur and thus produces no acidic compounds during combustion. One can also argue that wood combustion produces virtually no incremental CO_2 since the natural degradation of wood residue in a landfill site, or on the forest floor, for example, will produce the same CO_2 over a long period that combustion produces very rapidly.

The only other major combustion product is water in the form of steam which produces the characteristic white plume from the stack of a modern wood burning installation during cold weather.

Ash production is low at 1½ to 2 percent typically, and is environmentally benign.

Some plants are able to dispose of wood ash as fertilizer, although this is not generally true.

Perhaps, partially in recognition of some of these positive political aspects, the United States Government has passed legislation which encourages the development of small scale energy projects which sell electric power to the local utility at a price which reflects the cost to the utility of any new generation it might supply for itself, rather than the least costly source it might presently have at its disposal. This means that cogenerating plants which sell power to the utility can receive more for power sold than they pay for power purchased.

It is this legislation which has been the impetus behind the recent developments by Ultrasystems and US Energy in the State of Maine to build privately funded generating stations to produce electric power from localy produced wood residue fuel.

Four of these plants are in close proximity to western New Brunswick at Sherman Mills, Fort Fairfield, West Enfield and Jonesboro.

The US energy plant at Fort Fairfield is not fully operational at the time of writing, but could become a major potential market for New Brunswick residue. Canadian wood suppliers have indicated an interest in supplying more wood to these American plants.

Should the New Brunswick government decide to encourage a wood residue industry through the construction of wood burning electric power plants, for example, a major increase in demand for wood fuel could occur quite quickly.

9.0 PROJECTIONS OF AVAILABILITY, DEMAND AND COSTS OF RESIDUES

9.1 Availability of Wood Residue

In order to prevent the depletion of the resource base, there is a finite amount of wood which may be harvested in the Province in any one year (the maximum annual allowable cut or AAC) and therefore it should be possible to predict the maximum amount of residue which can be available in some form. Although silvicultural efforts will undoubtedly increase this allowable cut in the future, it is widely believed that a shortage of some types of wood will occur in the coming years. Therefore, the supply of residue is ultimately limited by the present allowable cut of roundwood.

The demand for and selling price of residues are clearly related to the cost of oil and, as recent experience has shown, it is hazardous to predict a trend in this area, although it would seem reasonable that in the long term, the cost of oil will move upward. Any large increase would create a strong upward movement in demand for residues and therefore should increase the price a consumer will have to pay to compete for the limited supply available.

The finite availability of residue fuel in a particular area means that as local demand increases, transportation costs become more important because of the need to go further afield to secure enough residue to satisfy demand. Thus, it is evident that the price of residue is somewhat site specific and is influenced by many factors.

Consumption Patterns for Wood Residues

1) Sawmill residues - Almost all sawmill residues produced at this time are presently being used. Advances in sawmill technology, such as thinner saws and more accurate cuts which reduce both sawdust and shavings generation, are occurring rapidly and will probably continue to do so in the future. Also, as the supply of large logs is declining, the smaller, less efficient mills will be forced out of business. Therefore, it appears that the present residue production from sawmills in the Province is probably at or near its maximum level. A gradual decline could be expected in the future as technology improves.

2) Harvesting residues - This sector offers by far the greatest potential for an increased supply of wood residues. Estimates indicate that there are 2 to 3 times the residue available from this source than is currently being used. At present there is very little utilization of this material. Equipment to process this material is already available or under development and, in the Scandanavian countries, large quantities of this harvest residue are collected and used. As described earlier in this report, the prototype "Logging Residue Processor" and similar equipment may have the potential to dramatically lower the current costs of production.

   Although the quantities of harvesting residues will not increase greatly in the future, the disposition of it probably will change due to the move towards more mechanized operations which bring the whole tree to roadside. Thus the residue will be in an ideal location for processing and trucking. This material must be removed in any case, and

the present practice of burning the slash in the forest is both costly and wasteful. This will likely be the most important source of new residue fuel supplies in the future.

3) Nonmerchantable Wood Whole Tree Chips

At present there is a surplus of hardwood species in certain areas of the Province. For example, in the southeast region there are stands of poplar which are not marketable at present. Northern New Brunswick has an abundance of hardwood growth for which there is presently no market.

As noted in Tables 2.5.2 and 2.5.3, these "surplus" stands could potentially produce 1,857,624 BD tonnes per annum of whole tree chips under ideal conditions.

However, at the time of writing, investigations are being carried out into the use of these presently unmarketable species for higher value-added purposes such as pulpwood and particleboard manufacture. It seems probable that today's "surplus" growth will eventually find a market that will provide more financial return to the provincial forest industry than could be provided by harvesting these stands for fuel wood.

There will always be a quantity of fire-killed timber available for salvage operations in various parts of the province, but the quantity and location of this material is completely unpredictable and is therefore impossible to include in the planning process for a specific wood burning plant.

Another potential source of whole tree chip production is the "energy plantation". Research has been done in Ontario on the development of fast-growing hybrid varieties of

poplar which can be rotated on a very short growth cycle. This technology has the potential to produce some wood fuel on an ongoing basis. Long-term effects of this form of "tree farming" on the forest soil are not clearly defined, and it is not likely that this approach will be widely used in N. B. in the immediate future.

Therefore, the total potential availability of residue from all sources is probably limited to the present production of mills (1,000,000 dry tonnes) plus the forest harvesting residue (2,700,000 dry tonnes) with no "surplus" wood available for a total "firm" availability of 3.7 million dry tonnes per year. Additional resources in the form of firekill and silvicultural waste should tend to supplement the residue supply.

Therefore, based on present information and observed conditions, it is likely that the maximum ultimate availability of wood residue on a sustained basis will remain at approximately today's level of 3,700,000 BDT for the next two decades. If it were possible to develop all of this resource, it would produce the additional energy equivalent of approximately 1.02×10^9 litres of No. 6 fuel oil per year beyond today's level of utilization (857,000 B.D.T.). Present consumption amounts to only approximately 23 percent utilization of the total of processing and estimated harvesting residue production.

9.2 Projected Costs of Wood Residue

The analysis of Section 6.0 as developed in the computer program provides the capability of projecting the cost of delivering a specific type of residue to a specific site once the transportation requirements are defined by the program user.

Assumptions as to the future inflation rates and costs of fuel oil can be varied to carry out sensitivity analyses for specific case studies.

The information contained in Section 1.0 of the present report indicates the disposition of harvesting activity in the province which provides a good guide to the potential availability of harvest residues in a particular area. This will have a bearing on the hauling distances involved when considering a particular installation, and should allow development of a first order cost analysis for any proposed plant.

It is essential to recognize the limitations of a generalized cost analysis. The costs associated with transportation, for example, assume a reasonable load factor on the trucks involved.

Thus, for a practical case involving small quantities of material, it is possible that actual costs could be much higher than that calculated by the model. However, in all real world cases studied, the trucks used to serve existing small sites are also used for other purposes or to serve other sites, and so the assumption of reasonable load factor is justified by practical experience.

The future cost for residues developed by the computer model depends, to some extent, on the judgement of the program user as to the general rate of inflation and that expected for fuel and oil.

The basic cost of the residue is dependent upon user selectable options as to the type of residue, and in the case of harvesting residues, the type of logging operation involved.

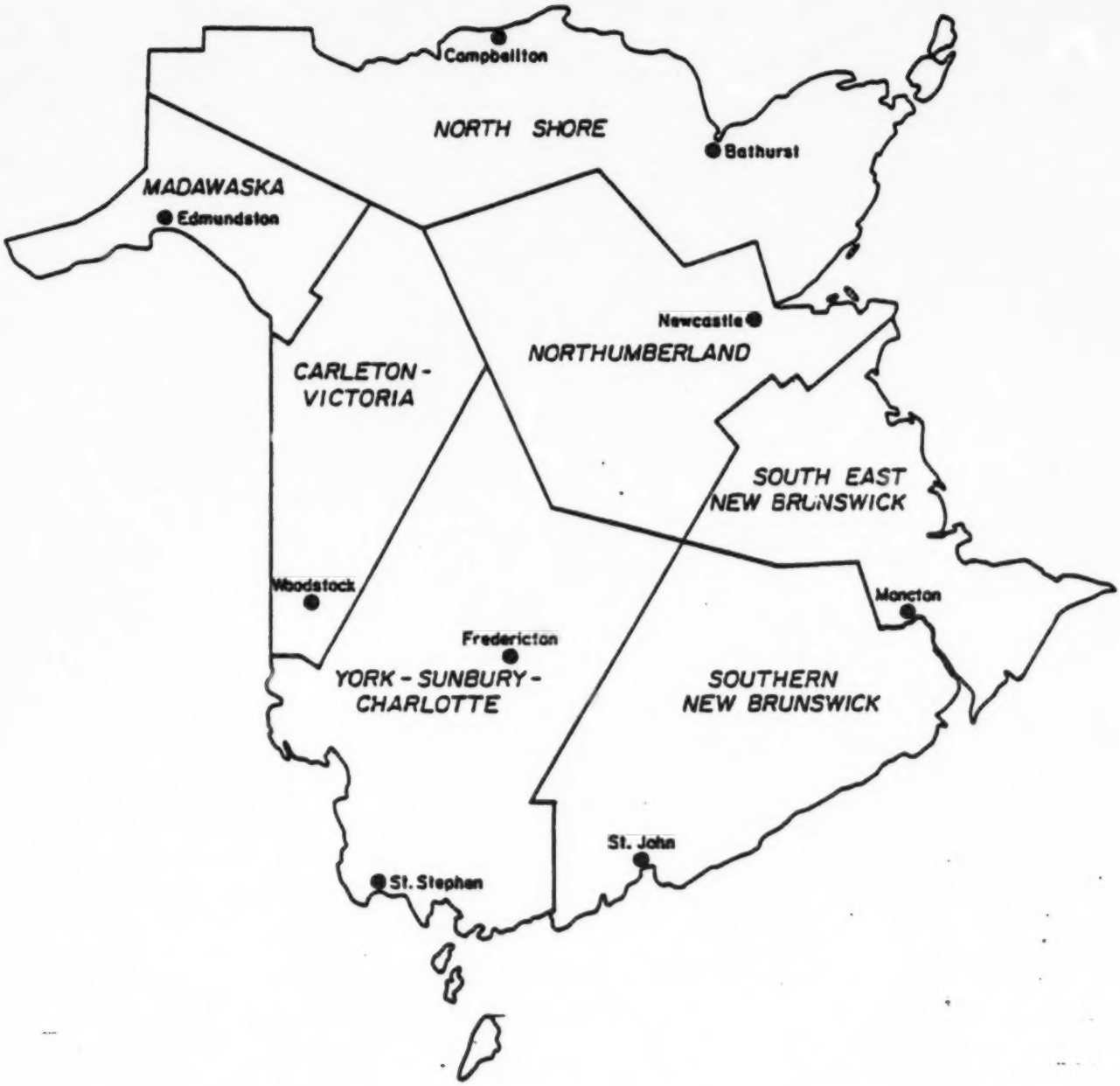
More subjective factors such as terrain, species and type of forest were considered as possible variables, but were not included because it was felt that these factors would not be significant in analyzing a general case.

Detailed instructions on the use of the computer program are included in Appendix D.

APPENDIX A

BOUNDARY MAPS

Crown Timber License Boundaries in
New Brunswick



Forest Products Marketing Boards in
New Brunswick

APPENDIX B

CONVERSION FACTORS

APPENDIX B

Harvesting Residue Assumptions

(1) 1 m^3 of hardwood = 1.04 green tonnes (0.52 BD tonnes)

(1) 1 m^3 of softwood = 0.87 green tonnes (0.44 BD tonnes)

Hardwood harvest is 19% of the Provincial total

Softwood harvest is 81% of the Provincial total

Therefore, weighted average = 19% x 1.04 = 0.20

81% x 0.87 = 0.70

0.90 green tonnes

m^3 (solid) of roundwood = .90 green tonnes

(2) If 60% is stemwood = 0.90 green tonnes/m^3 (solid) stemwood
(2) Then 40% is residue = 0.60 green tonnes/m^3 (solid) stemwood

Assume 50% M.C. (wet basis)

Therefore, 0.3 BD tonnes of residue is generated for each m^3 (solid) harvested.

Surplus stands (whole tree chip harvest potential)

for Hardwood (2) 60% is stemwood = 104 green tonnes/m^3 (solid) stemwood

(2) 40% is residue = 0.70 green tonnes/m^3 (solid) stemwood

1.74 green tonnes

= .87 BDT/m^3 (solid) stemwood (or roundwood)

Since AAC* figures are based on stemwood (or roundwood) volume, we conclude that each m^3 (solid) of hardwood AAC would yield .87 BD tonnes of whole tree chips.

for Softwood (2) 60% is stemwood = 0.88 green tonnes/m^3 (solid) stemwood

(2) 40% is residue = 0.58 green tonnes/m^3 (solid) stemwood

= 1.46 green tonnes

= .73 BD tonnes/m^3 (solid) stemwood

*AAC = Annual Allowable Cut

(1) Reported values in commercial use: Valley Forest Products Ltd.

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APPENDIX C

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REFERENCES

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APPENDIX D

COMPUTER PROGRAM OPERATING INSTRUCTIONS

This program is intended to run on an IBM AT or AT compatible computer. However, the program will run on an IBM XT or XT compatible computer, but with a reduced response time. A bootable floppy has been created which contains all of the necessary files required for the operation of the program. The program can be started by inserting the floppy into drive A and then turning on the machine. The program is structured so that once started, a prompt tells the user to insert the data disk. This disk should be formatted and the file COMMAND.COM copied from the ROOT DIRECTORY to the newly formated disk prior to starting the program. The following instructions will complete this task:

C:CD/<RET>
C:FORMAT A:/4<RET>
C:COPY COMMAND.COM A:COMMAND.COM <RET>

It is important that the computer be booted from the program floppy disk provided, as this floppy contains the information required to set up the virtual disk in the computer's RAM memory. If the computer is booted by some other means, the virtual disk will not be allocated, thus reducing the program speed greatly and causing unnecessary wear on the hard disk.

Once the program has been started, the first prompt is for the user to insert the data disk.

Once this disk has been inserted, the program prompts the user to select from the master index (reference Figure 1). The user can select the option desired by moving the cursor up or down with the up or down arrow key. The option identified by the cursor will become highlighted. Either the enter key or the space bar will select the option identified by the cursor.

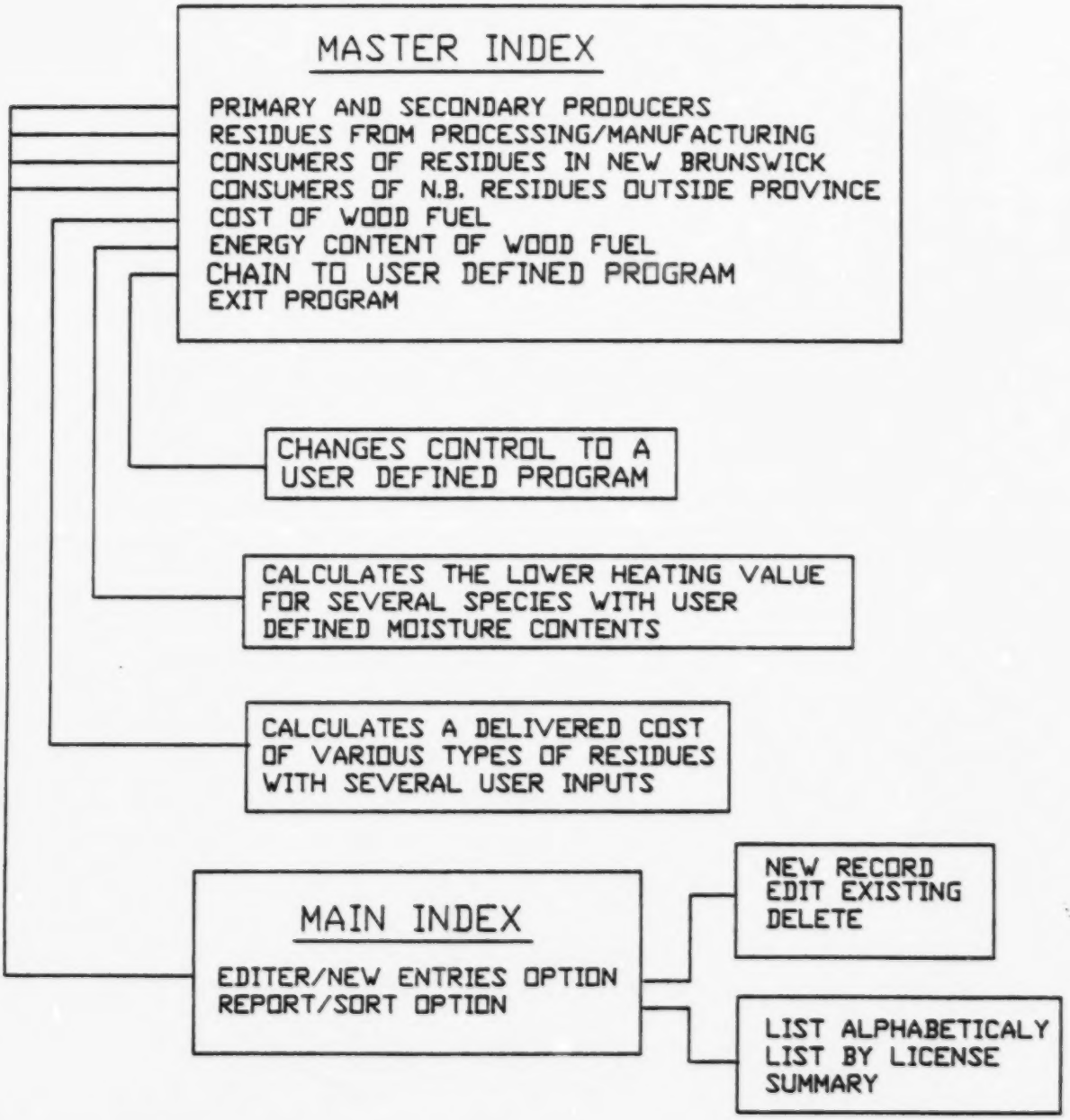
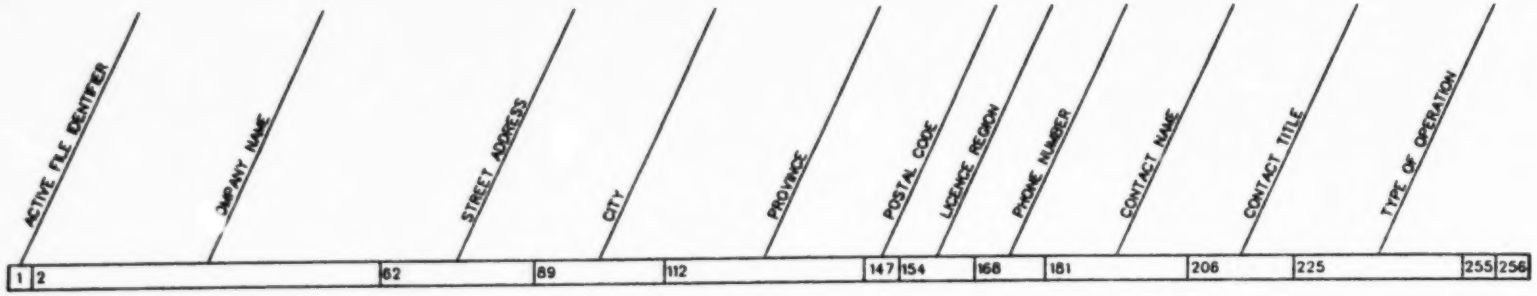
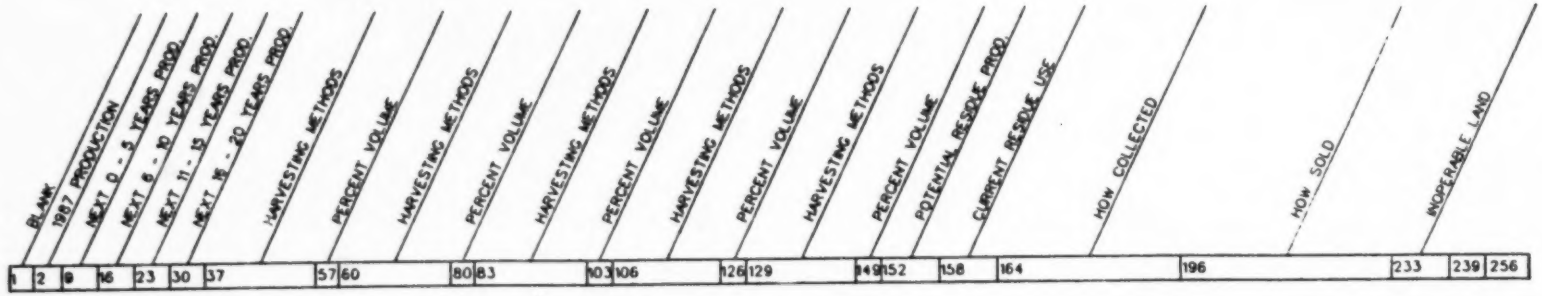

MASTER INDEX
PRIMARY AND SECONDARY PRODUCERS
RESIDUES FROM PROCESSING/MANUFACTURING
CONSUMERS OF RESIDUES IN NEW BRUNSWICK
CONSUMERS OF N.B. RESIDUES OUTSIDE PROVINCE
COST OF WOOD FUEL
ENERGY CONTENT OF WOOD FUEL
CHAIN TO USER DEFINED PROGRAM
EXIT PROGRAM
CHANGES CONTROL TO A USER DEFINED PROGRAM
CALCULATES THE LOWER HEATING VALUE FOR SEVERAL SPECIES WITH USER DEFINED MOISTURE CONTENTS
CALCULATES A DELIVERED COST OF VARIOUS TYPES OF RESIDUES WITH SEVERAL USER INPUTS
MAIN INDEX
EDITER/NEW ENTRIES OPTION
REPORT/SORT OPTION
NEW RECORD
EDIT EXISTING
DELETE
LIST ALPHABETICALY
LIST BY LICENSE
SUMMARY

FIGURE 1
GENERAL FLOWCHART FOR
COMPUTER PROGRAM

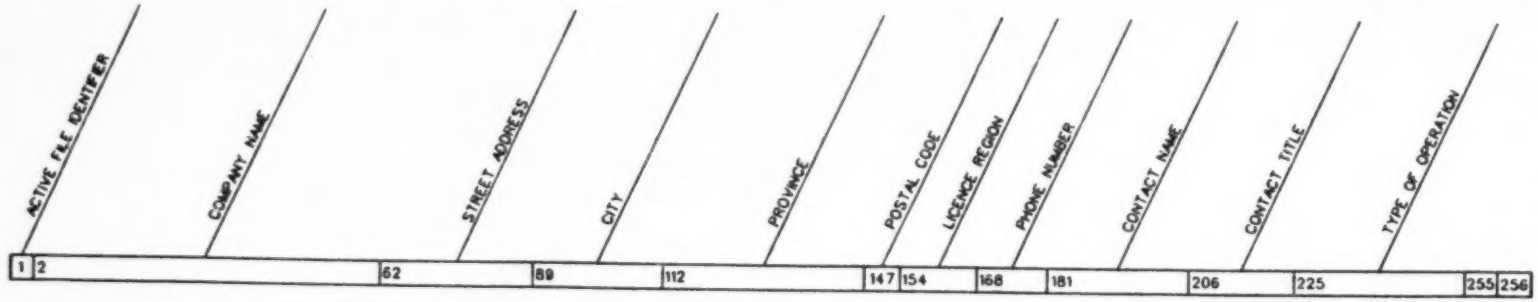


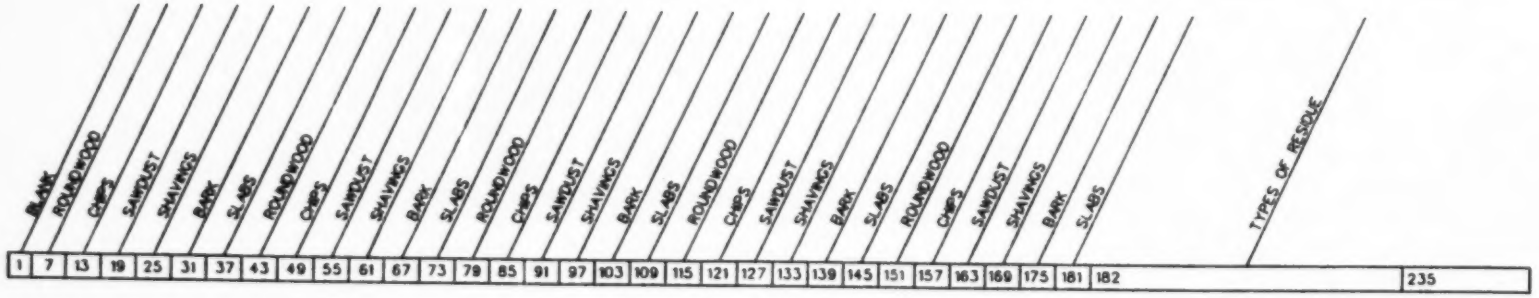


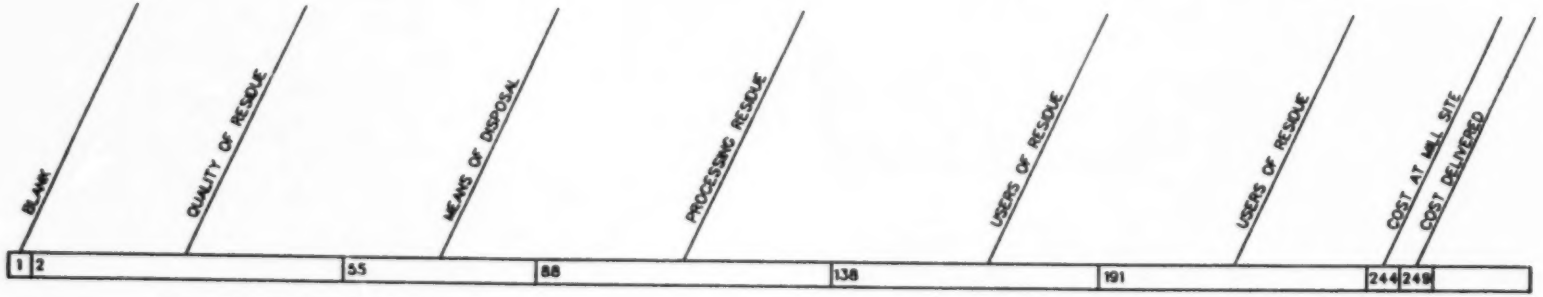
ECONOMIC AVAILABILITY OF WOOD RESIDUES FOR FUEL IN THE PROVINCE OF N.B.

DATA STORAGE STRUCTURE FOR PRIMARY AND SECONDARY PRODUCERS

Project 185-59
Dwg FIG. 2
Scale
Rev No. 0





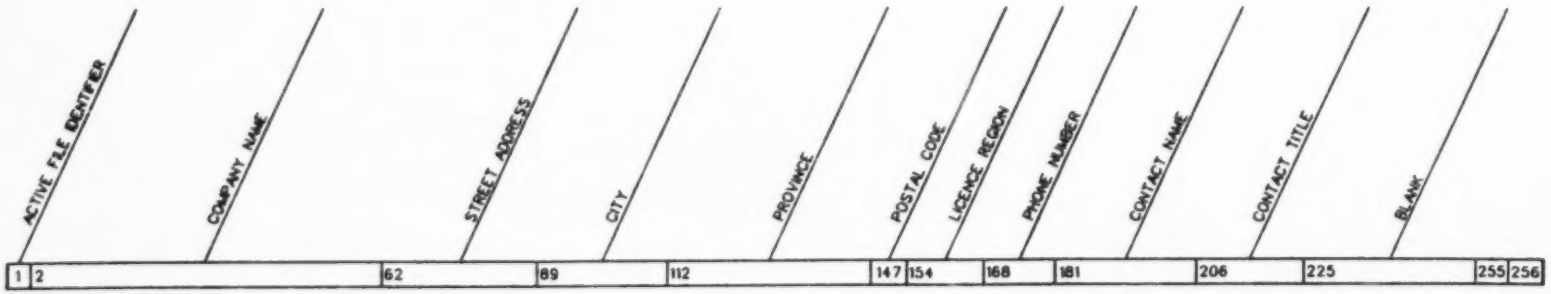


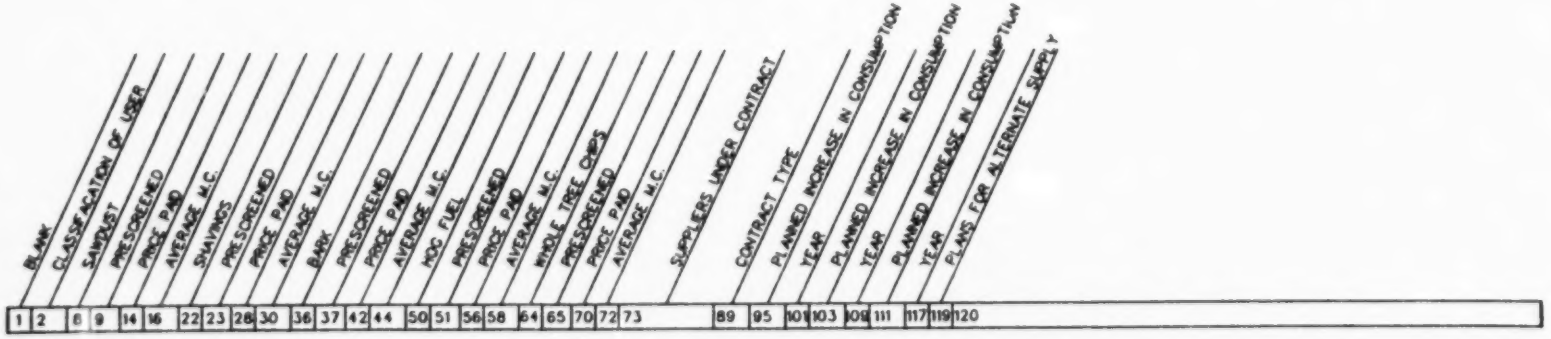
Drawn By	D.R.J.		
Design Check By			
Quality By	K.J.B.		
Quality Check By			
Date Drawn	OCT./87		
Date Issued			
Authority By			

ECONOMIC AVAILABILITY OF WOOD RESIDUES FOR FUEL IN THE PROVINCE OF N.B.

DATA STORAGE STRUCTURE FOR PROCESSING AND MANUFACTURING

Project	185-58
Drawing	FIG. 3
Scale	
Revision No.	0





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Design Chk'd By
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ECONOMIC AVAILABILITY OF WOOD RESIDUES FOR FUEL IN THE PROVINCE OF N.B.

Dwg. Title
DATA STORAGE STRUCTURE FOR CONSUMERS OF N.B. RESIDUES

Project 185-58
Dwg. FIG. 4
Scale
Rev. No. 0